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ENGINEERING EXPERIMENT STATION
OREGON STATE UNIVERSITY
CORVALLIS, OREGON

Wood Residue Incineration In Tepee Burners

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By

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ACKNOWLEDGMENTS

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The many students and co-workers of the author who have worked on the problems of wood combustion in tepee burners over the past several years have gathered most of the data reported. Some of their names may be found in the Bibliography of this circular.

INTRODUCTION

The lumber and plywood manufacturing processes generate large quantities of residue or waste material. Some of this material is converted to useful by-products such as chips for pulp, particle board, Presto logs, and even to heat which is utilized for electrical power or steam. The remaining residue is usually incinerated at the mill site in a tepee-shaped, single-walled, steel waste burner. The amount and type of residue fed to the waste burner depends upon the practices of the particular mill, species of log being processed, and mill location with respect to by-product markets.

Two technical publications are available through the Engineering Experiment Station of Oregon State University which deal with the incineration of wood residue in tepee burners.[1,2] Both of these publications suggest ways of reducing the particulate emission from tepee burners, but neither dwells extensively on the practical combustion aspects of the burner. Another recent study[3] evaluates the tepee burner as a contributor of air pollutants and again suggests improvements which might be made.

The Oregon State Sanitary Authority has become increasingly concerned with tepee burners as sources of air pollutants in recent years. They have drafted regulations which will put the burners in the State of Oregon under much tighter control.

This circular has been prepared to give the person in the field some practical information concerning combustion in tepee waste burners. The tepee burner is not a desirable incinerator from an air pollution standpoint, but by optimizing the combustion conditions for each individual burner the pollutants can be minimized.

PROPERTIES OF WOOD AS A FUEL

Wood is probably man's oldest fuel and the combustion of wood probably man's first attempt to use a chemical process for his betterment. Combustion is defined as the union of a substance with oxygen accompanied by the evolution of heat and light. Even though scientists do not completely understand all the mechanisms of combustion, they can use the combustion reaction to their advantage. Combustion may be used to produce energy, as in an automobile or a steam generator, or as a destructive reaction to eliminate an unusable material. The latter is the case in the waste burner.

Ultimate Analysis

Wood can be a widely varying fuel with different physical and chemical properties, depending upon the species, age, location, etc. A chemical analysis for dry Douglas-fir would indicate the following percentages of material:

Hydrogen	6.3%
Carbon	52.3%
Nitrogen	0.1%
Oxygen	40.5%
Ash	0.8%

Such an analysis is called an Ultimate Analysis. All noncombustibles are lumped together as ash.

Proximate Analysis

Another type of analysis used by combustion engineers is the Proximate Analysis. This analysis indicates how the fuel will be burned. The Proximate Analysis for dry Douglas-fir would be:

Volatile Matter	82.0%
Fixed Carbon	17.2%
Ash	0.8%

The heating values of wood will vary considerably. Dry Douglas-fir has a heating value of 9,050 Btu per pound. This is only about one-half the heating value of petroleum products. The main reason it is lower is the high oxygen content which in this respect dilutes the heating value of the wood.

Steps in Wood Combustion

The steps in wood combustion are rather specific and well defined. Assume a pile of fuel, such as in a tepee burner; fresh fuel falls on the top of the pile where it is dried as the moisture is driven off. This is an endothermic process in that it requires heat.

The volatiles are next distilled from the wood. These may be combustible gases (hydrocarbons) or noncombustibles (oxygen and nitrogen). The process is endothermic because it requires heat for the distillation and also exothermic because the volatile gases are burned. This combustion takes place above the fuel pile where sufficient oxygen is available. The combustion reactions of interest are: (1) $C + O_2 \rightarrow CO_2$ and (2) $2H_2 + O_2 \rightarrow 2H_2O$.

After the volatile matter has all been distilled off, all that remains is the fixed carbon. This is the material of which the briquets, which are used in home barbecues, are made. This fixed carbon is burned in the fuel pile if sufficient oxygen is available ($C + O_2 \rightarrow CO_2$). The heat is all released within the fuel pile if the combustion is complete. If not enough oxygen from the air is available, the reaction in the pile is: $2C + O_2 \rightarrow 2\,CO$ and only a portion of the heat is released within the pile. The remainder of the reaction takes place over the pile where sufficient oxygen is available: $2\,CO + O_2 \rightarrow 2\,CO_2$. Additional heat is released in this reaction.

The remaining material that is left after combustion is the ash. This collects at the base of the pile and must be periodically disposed of.

Combustion in a Tepee Burner

When we analyze the combustion in a waste burner, we have simply enclosed the open fuel pile within a shell. Figure 1 illustrates such a situation.

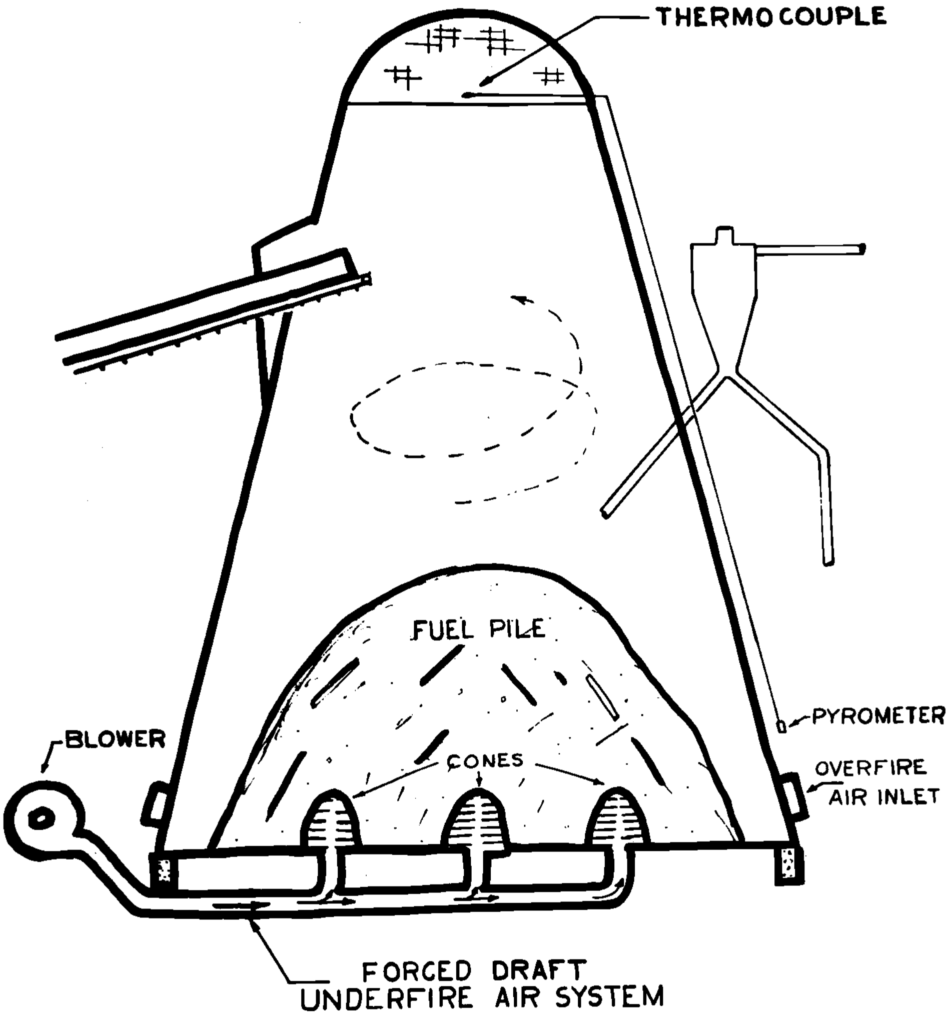


Figure 1.
Typical Tepee Waste Burner

To dry the incoming fuel, the combustion products H_2O and CO_2 may be used. These were generated from the combustion of H_2 and C. O_2 and N_2, which were forced through the hot fuel pile by the forced-draft system, help dry the fuel. Radiant heat from the shell will also help to dry the fuel. The radiant heat is a function of the absolute temperature squared, so a cool shell doesn't help dry much fuel.

To distill the volatiles, the hot CO_2 and CO are available from the combustion of the fixed carbon below. The hot O_2 and N_2, which were forced through the burning bed, are available as heat sources. Again the radiant heat from the shell is available.

The fixed carbon is burned in the pile. If enough forced-draft air is supplied, it burns to CO_2 in the pile. Any CO generated burns above the pile.

Of course the ashes accumulate at the bottom and must be periodically removed to keep the forced-draft system operative.

It is apparent that once sufficient oxygen is supplied to complete the combustion, additional oxygen (and its associated nitrogen) will only tend to cool the reacting products and the exhaust gases. Air greater than theoretical is termed "excess air." Test data from several waste burners indicate that exhaust-gas temperatures may be related to excess air as shown in Figure 2. Because of this relationship a good indication of excess air may be obtained if the exhaust-gas temperature of the burner is known. The usual procedure for determining the amount of excess air from a combustion process is to take an exhaust-gas analysis, and from the fuel analysis and gas analysis calculate the excess air. For Douglas-fir such a calculation yields a curve as shown in Figure 3.

It has been generally found from field observations that if tepee burners can be operated so that the temperature of the gases leaving the top of the burner are greater than 600° F, the smoke and other particulate will be minimized. A maximum temperature of 900° F is recommended, which leaves a satisfactory margin of safety before structural damage occurs. A summary of several field observations of smoke and exit-gas temperatures is shown in Figure 4. The following table summarizes what has been presented concerning temperature, excess air, gas analysis, and smoke.

Exit-Gas Temperature, °F	600	900
Excess Air, %	550	200
CO_2 in Exit Gas, %	3	6+
Probable Smoke Condition	slight to none	none

Table 1.
Desirable Operating Range for Tepee Burners

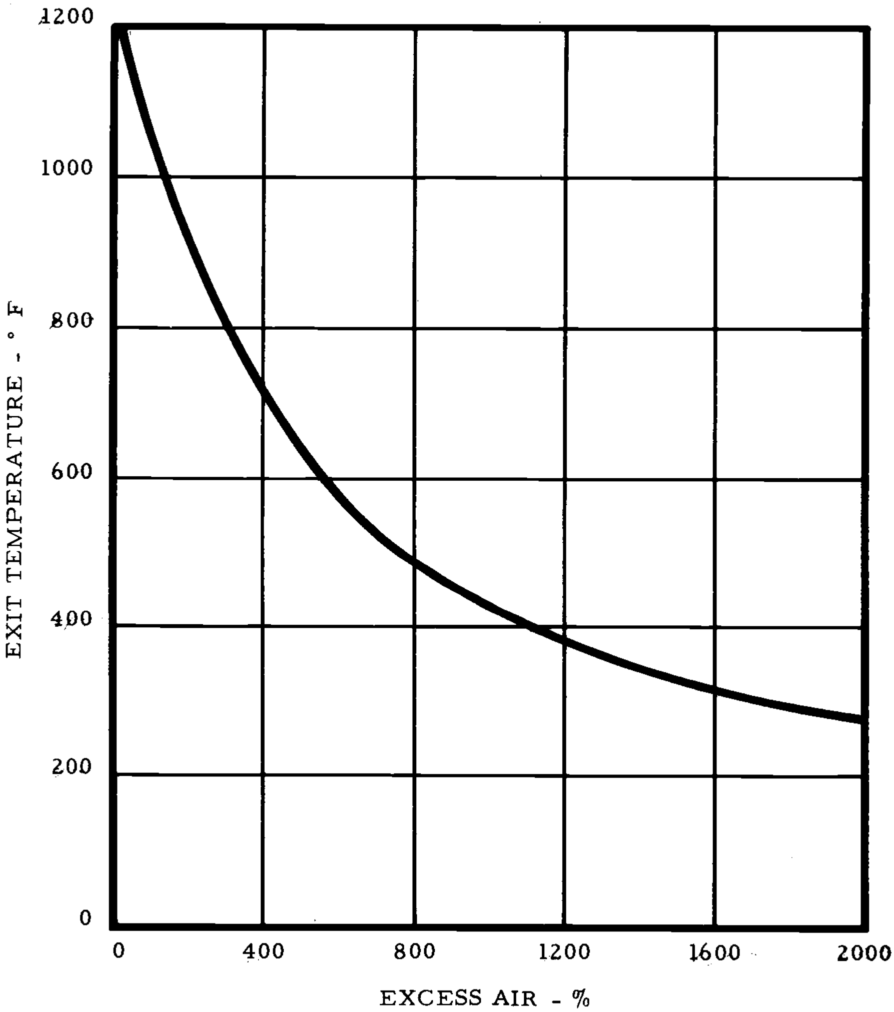


Figure 2.
Correlation Between Temperature
and Excess Air

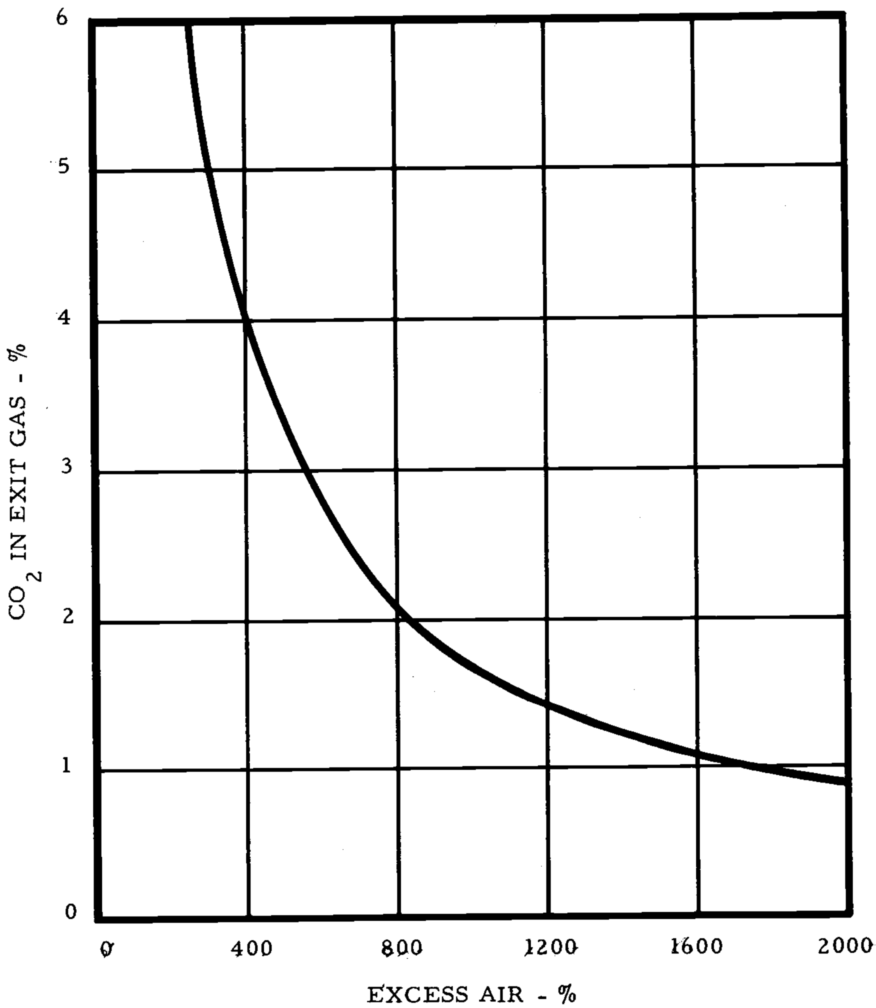


Figure 3.
Correlation Between CO_2 and
Excess Air for Douglas-fir

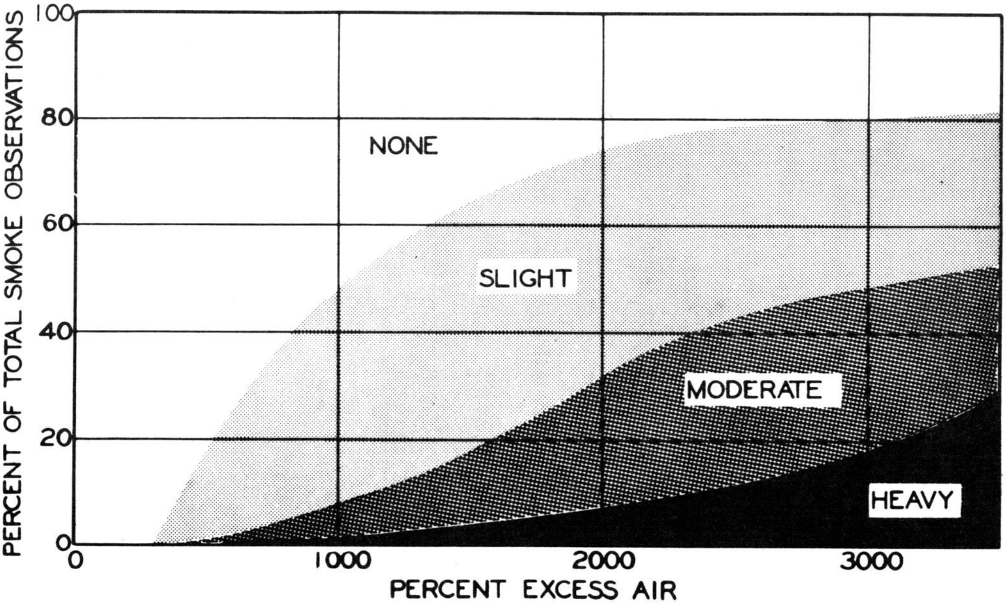


Figure 4.
Relationship Between Smoke
and Excess Air

DESIGN OF A WASTE BURNER

The size of a burner to consume a given quantity of waste is fairly critical. Too large a burner will operate at a low temperature and smoke severely, while too small a burner will emit burning material. The correct size of a burner may be determined from the equation:

$$D = 2.3Q^{1/3}$$

where

D = diameter of base and height, ft
Q = quantity of waste, lb per hr

Figure 5 is a graph of this sizing equation.

Example

An example of a typical burner design problem is the best way to illustrate the necessary calculations. For the example mill, assume the following as the necessary design factors:

Species - Douglas-fir (50% moisture and 50% dry wood)
Amount of Waste - 25,000 lb/hr (wet)
Desired Excess Air - 500% (which corresponds with 650° F exit-gas temperature)

Sizing

The sizing curve, Figure 5, indicates that for 12.5 tons per hour of wet fuel a 65-foot burner will be needed. The sizing equation verifies this:

$$\begin{aligned} D &= (2.3)\sqrt[3]{25{,}000} \\ &= (2.3)(29.25) \\ &= 67.2 \text{ ft} \end{aligned}$$

Air Supply

The air supply to the burner should be calculated so that sufficient forced-draft air is supplied to burn the fixed carbon. All other air, including the excess, should be supplied over the fire to burn the volatile gases and cool the exhaust products.

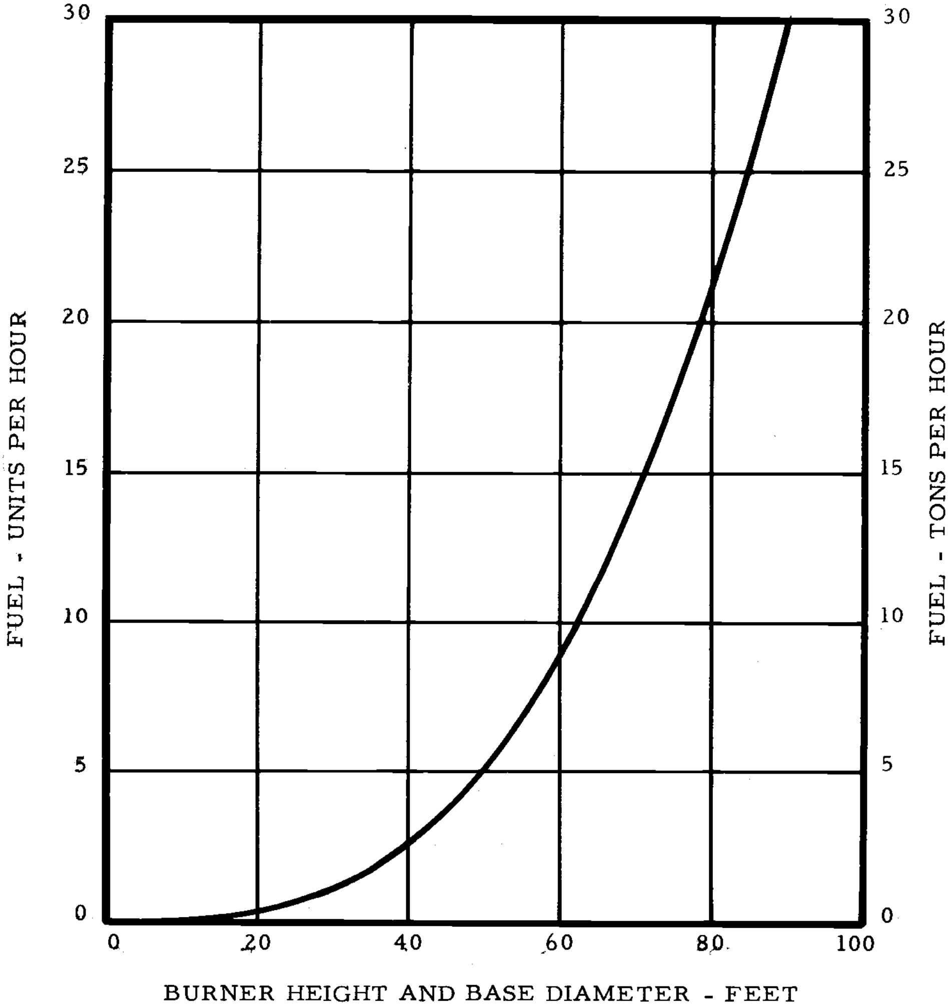


Figure 5.
Burner Size Diagram

Air for Forced Draft

Each pound of dry wood contains 0.17 pounds of fixed carbon: $C + O_2 \longrightarrow CO_2$, so each 12 pounds of carbon requires 32 pounds of oxygen for complete combustion.

$$\frac{0.17 \text{ lb C}}{\text{lb fuel}} \times \frac{32 \text{ lb } O_2}{12 \text{ lb C}} \times \frac{100 \text{ lb air}}{23 \text{ lb } O_2} = \frac{1.97 \text{ lb air}}{\text{lb fuel}}$$

A 50 percent overload capacity for the forced-draft system should be provided, so:

$$(150\%)\ \frac{1.97 \text{ lb air}}{\text{lb fuel}} = \frac{2.95 \text{ lb air}}{\text{lb fuel}}$$

Calculating this volume at the fan:

$$\frac{2.95 \text{ lb air}}{\text{lb fuel}} \times \frac{\text{ft}^3 \text{ air}}{0.075 \text{ lb air}} \times \frac{12{,}500 \text{ lb dry fuel}}{\text{hr}} \times \frac{\text{hr}}{60 \text{ min}} = 8{,}200 \text{ cfm}$$

Air for Overfire

Carbon in volatile matter needs air:

$$C = \frac{0.52 \text{ lb C}}{\text{lb fuel}} - \frac{0.17 \text{ lb fixed C}}{\text{lb fuel}} = \frac{0.35 \text{ lb volatile C}}{\text{lb fuel}}$$

The theoretical air required is:

$$\frac{0.35 \text{ lb C}}{\text{lb fuel}} \times \frac{32 \text{ lb } O_2}{12 \text{ lb C}} \times \frac{100 \text{ lb air}}{23 \text{ lb } O_2} = \frac{4.06 \text{ lb air}}{\text{lb fuel}}$$

Hydrogen in volatile matter needs air. The theoretical air required is: $2H_2 + O_2 \longrightarrow 2H_2O$, so each 4 pounds of hydrogen requires 32 pounds of oxygen for combustion.

$$\frac{0.06 \text{ lb } H_2}{\text{lb fuel}} \times \frac{32 \text{ lb } O_2}{4 \text{ lb } H_2} \times \frac{100 \text{ lb air}}{23 \text{ lb } O_2} = \frac{2.09 \text{ lb air}}{\text{lb fuel}}$$

The total overfire air for theoretical combustion is the amount for the carbon plus the amount for the hydrogen minus the amount which the oxygen in the fuel can supply. In other words, the air needed can be reduced by the amount of oxygen in the fuel plus the associated amount of nitrogen. The reduction in air because of oxygen in the fuel is:

$$\frac{0.405 \text{ lb } O_2}{\text{lb fuel}} \times \frac{100 \text{ lb air}}{23 \text{ lb } O_2} = \frac{1.76 \text{ lb air}}{\text{lb fuel}}$$

Theoretical overfire air is therefore:

$$\text{Air for C + Air for } H_2 \text{ - Air replaced by } O_2 =$$

$$\frac{4.06 \text{ lb air}}{\text{lb fuel}} + \frac{2.09 \text{ lb air}}{\text{lb fuel}} - \frac{1.76 \text{ lb air}}{\text{lb fuel}} = \frac{4.39 \text{ lb air}}{\text{lb fuel}}$$

Five hundred percent excess air means that we must supply six times the theoretical so:

$$\text{Overfire air} = (6)\ \frac{4.39 \text{ lb air}}{\text{lb fuel}} = \frac{26.34 \text{ lb air}}{\text{lb fuel}}$$

The volume of overfire air is:

$$\frac{26.34 \text{ lb air}}{\text{lb fuel}} \times \frac{\text{ft}^3 \text{ air}}{0.075 \text{ lb air}} \times \frac{12{,}500 \text{ lb dry fuel}}{\text{hr}} \times \frac{\text{hr}}{60 \text{ min}} = 73{,}170 \text{ cfm}$$

To size the overfire-air openings, the draft must be calculated. At 650° F the exit gases have a weight compared to the surrounding air of:

$$\frac{70 + 460}{650 + 460} \text{ or } 47.7\%$$

In a 65-foot burner the draft produced would be:

$$(1.000 - 0.477)\ 65 \text{ ft} = 34 \text{ ft of air}$$

(A draft gauge at the base of the burner would read this as about 1/2 inch of water.)

The velocity through the overfire-air openings produced by this draft would be:

$$V = \sqrt{2gh} = \sqrt{(64.4)\ \frac{ft}{sec^2} \times 34\ ft} = 46.8\ fps$$

The area of the overfire-air openings would be:

$$A = \frac{Q}{V} = \frac{73{,}170\ ft^3}{min} \times \frac{sec}{46.8\ ft} \times \frac{min}{60\ sec} = 26\ ft^2$$

Assuming a 50 percent oversize to take care of any overload, the overfire-air openings would have to have a combined volume of 39 ft^2. This could be accomplished, for example, by using ten 2-foot by 2-foot openings.

The overfire-air openings should be of the tangential type, with dampers for the control of the air volume passing through them. The damper design should be such that it does not interfere with the cyclonic action induced by the tangential openings when the dampers are partially closed.

The air supply for the burner would be 8,200 cfm forced draft, or underfire air, and 73,170 cfm overfire. This breaks down to a total of 81,370 cfm of which 10 percent is supplied by the forced-draft sytem. Two 15-horsepower centrifugal fans would adequately supply the forced-draft requirements.

Propeller fans are not recommended for forced-draft systems on waste burners. Propeller fans are designed for high-volume flows at low-static pressures, and the forced-draft system will be easily plugged if they are used.

WASTE BURNER CONSTRUCTION

Most construction details have been standardized by the industry. A statement of some, however, seems appropriate. All structural members should be external to the shell. This will enable them to carry the load and be shielded from the heat within the burner. Some builders are using annular trusses, particularly at the top of the burner. At high operating temperatures the truss is not weakened and satisfactorily supports the shell plates.

Adequate doors and other provisions must be made for cleaning the burner. Doors should be sized so that a loader, or similar vehicle, can enter the burner. The forced-draft system must be designed to carry the weight of the loader. If projections, such as cones or elbows, are used in the forced-draft system, they should be removable or protected during the cleaning operation.

The fuel should be admitted as low in the burner as possible. This can be aided by using water-cooled conveyor bearings which allow for an overhang of the conveyor system. Discharge pipes from air-cyclone conveying systems should deposit their planer shavings, sawdust, etc., as low as possible to permit combustion of these small bits of fuel rather than entrainment in the exit gases.

Draft Systems

The forced-draft system should be designed to give even air distribution throughout the entire fuel pile. One of the most satisfactory systems has been the one manufactured by the Medford Steel and Blowpipe Company, P. O. Box 1147, Medford, Oregon. Figure 6 illustrates this system. If the elbows should become uncovered, they aid the tangential action of the overfire-air system. The two blowers are also arranged so that the outer ring can be shut down if a small pile is all that exists in the burner.

Dampers should be provided in the forced-draft system to throttle the flow of air under startup and light load conditions. These may be either at the fan inlet or outlet, but they should be equipped with some type of position indicator so that settings may be consistent once proper operation is established.

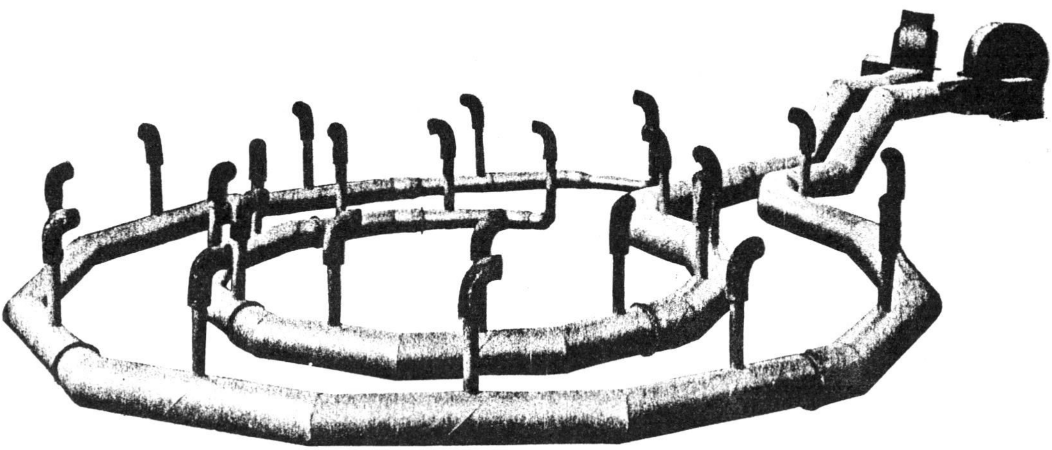


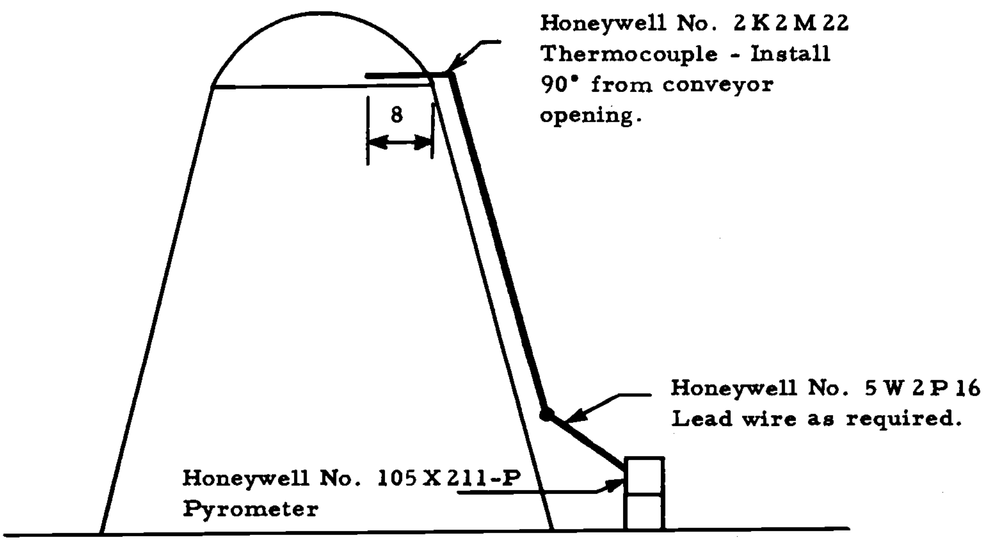
Figure 6.
Medford Steel and Blowpipe
Forced-Draft System

The overfire-air system should contain suitable dampers at each port. Barometric dampers have been used, but they require delicate adjustments which tend to change as the bearings and shafts weather and corrode. Most satisfactory systems are manually adjustable with the ports and dampers arranged so that they are not damaged by falling slabs, edgings, or other fuel.

Thermocouple

A very necessary and inexpensive part of the waste burner is a thermocouple installed at the top to indicate exit-gas temperature. This will permit the burner to be operated at optimum conditions for disposal of waste with a minimum of atmospheric pollution. Figure 7 shows a very satisfactory arrangement for such a thermocouple system which can be installed for less than $300. The thermocouple is relatively trouble free and with normal maintenance will outlast the burner itself.

NOTE: Pyrometer installed in weatherproof housing furnished by owner. Locate at eye level (approx. 5 ft) at least 15 ft from burner shell.



INSTALLATION DRAWING
Figure 7.

Thermocouple with Indicating Pyrometer

TEPEE BURNER COSTS

Exact costs for tepee burners are difficult to establish because each mill is unique as far as its physical layout is concerned. Approximate costs are available, however, and past experience has shown them to be reliable enough for most purposes.

Construction Cost

The following would be an approximate estimation for a 40-foot burner installed at the mill site:

Burner structure and shell	$ 5,600
Concrete base	1,500
Forced-draft system (Medford S and B)	1,940
Thermocouple and pyrometer	200
TOTAL	$ 9,240

For a 60-foot burner installed the approximate cost would be:

Burner structure and shell	$10,450
Concrete base	1,700
Forced-draft system (Medford S and B)	3,950
Thermocouple and pyrometer	200
TOTAL	$16,300

The above costs are exclusive of conveyors and other fuel handling systems. A reasonable estimating cost for a conveyor is $50 per lineal foot.

Operating Cost

The costs of disposing of the wood residue are seldom computed by mill owners. If they would run a simple cost analysis, they would probably treat their burner with more respect. For instance, suppose a mill is using a 60-foot burner with 80 feet of conveyor to dispose of 20,000 pounds of wet residue per hour (10 units per hour). The cost analysis, based on an original burner plus conveyor cost of $20,000, would be:

Taxes at 2%	$ 400	per year
Interest at 6%	1,200	
Depreciation at 20%	4,000	
Insurance at 0.1%	20	
Labor of firing 2 hr/day	1,250	
Labor of cleaning and maint. 4 hr/wk	520	
Power cost of 75 hp blower and conveyor at 9 mill/kw hr	2,700	
TOTAL	$10,090	per year

If the mill operates two shifts, the cost per unit works out to be $0.25 per unit. If the mill operates only one shift or disposes of less than 10 units per hour, the cost rises accordingly.

TEPEE BURNER OPERATION

The correct firing of a tepee burner becomes both an art and a science. A properly operated burner will dispose of the residue with a minimum of smoke and other pollutants. A poorly fired burner will smoke and deposit particulate over a wide area even though it may be properly sized and designed. One of the most common mistakes is to fire the burner with the access door open. This severely upsets the draft balance and air distribution in a properly designed burner. The fire may appear to burn more rapidly for a short period of time because the fuel pile glows more. This is due to the increased "forge effect" on the fixed carbon. Fixed carbon is only about one-seventh of the fuel by weight. Firing with the door open, in order to get apparently better combustion for a relatively small percentage of the fuel, actually chills the volatile gases and hinders their combustion. If the forced-draft system was adequate and properly operated in the first place, opening the door would not aid the combustion of the fixed carbon. An open access door on an operating tepee burner is a glaring indication that something is improper with the design, loading, or operation of the burner.

Written Log

A written log is necessary for proper burner operation. Only if entries concerning draft settings, gas temperature, smoke, fuel, etc., are faithfully made will the operator know the optimum firing situation. If it is noted in the log that a certain series of settings gave smokeless operation for a particular fuel load and type, then the settings can be used for future firings. If no written record is available, the proper settings are quickly forgotten. A suggested form for the written log is given on the following page. It can be modified for any particular burner or mill.

Startup

Probably the most difficult period of burner operation is during the startup. The residue starts coming from the mill and the burner is expected to handle it. Unless the burner is previously heated and contains a good fire, this fresh residue will tend more toward a fire

BURNER LOG

Date ______________________ Operator ______________________

Name of Co. ______________________ Est. Hourly Production ______________________

Address ______________________ Est. Hourly Waste to Burner ______________________

Burner Size ______________________ Species and Type of Waste ______________________

Time	Overfire Draft Setting	Forced Draft Setting	Exit Gas Temp.	Smoke Density and Color	Fallout Emission	Weather	Wind Direction and Velocity	Auxiliary Fuel Used	Remarks

extinguisher than a fire supporter. An adequate fire must be started in the burner well before the first residue is sent to it. An hour before the start of production is a good time to get the burner operating. Dry planer ends, slabs, edgings, etc., should be accumulated from the previous day's operation and available to build a satisfactory fire in the burner. The fire should be built and started with the overfire-draft doors closed and the underfire air set very low. A good-sized preliminary fire should be the goal by startup time of the mill. Once the residue starts entering the burner from the mill, the fire will sustain itself only if proper control of the air supply is exercised. The general tendency is toward too much overfire air, which only tends to excessively chill the fresh fuel. Cold air does a poor job of drying wood fuel! The overfire air should be kept from the fire until the fire is self-sustaining, and then the draft doors should be slightly opened to admit more air. Once full combustion is under way, the draft settings may be opened to their normal operating positions.

Continuous Fueling

Combustion is properly established when the fuel is consumed at the same rate it enters the burner. The operator should adjust the burner so that the exit-gas temperature is between 600° F and 900° F and smoke and particulate are at a minimum. A good clue to overall burner operation is smoke. Since smoke is particulate, it indicates how well the fire is consuming the residue material. With "no smoke" you can be sure that the burner is doing its best job and that a minimum of pollutants and particulate are leaving the top of the burner.

Slight adjustments in burner operation may have to be made even during periods of apparently continuous operation. Waste quantities will vary or even stop completely during breaks and lunch hour. Weather or wind changes will affect the combustion. The fireman should be continually aware of the situation and make small corrections to the draft settings as required.

Shutdown

Another critical period in burner operation is when production stops for the day. If the burner has been properly operated, only a normal fuel pile will exist inside. About one-half hour after the mill stops this will be reduced to practically 100 percent fixed carbon, and the overfire draft doors should be closed. Only after the fixed carbon has been consumed may the forced-draft blowers be shut off.

If the burner was not operating properly during the period of mill production, an extremely large fuel pile may have accumulated by the end of the working day. A fireman must remain in attendance at the burner until this large pile is consumed. Many burners have been badly damaged because a large fuel pile fell against the side of the burner and the excessive heat and lack of cooling buckled the structure and shell.

Cleaning and Maintenance

Care of the burner is another important factor for proper firing with a minimum of pollution. The burner should be completely cleaned of ashes at least once a week. A thorough inspection should accompany this cleaning and any faults or defects reported to the millwright or maintenance superintendent. Leaks in the shell and warped doors are more easily spotted from inside the burner than from outside. If repairs are needed, they should be made immediately to put the burner back into proper operating condition. Remember that the burner costs the mill owners somewhere around $10,000 per year. It deserves to be treated with care.

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APPENDIX

Included in the Appendix are the following:

1. A "Burner Data Sheet" which might be useful to anyone or any group which would be making a survey of several burners. This form enables a standard tabulation to be conducted.

2. The regulations of the Air Quality Control section of the Oregon State Sanitary Authority concerning waste burners. At the date of printing of this circular these regulations had not been codified nor filed with the Secretary of State. These were developed through a cooperative effort between the Sanitary Authority, Forest Industries Air Quality Committee of Associated Oregon Industries, and Oregon State University.

3. Analyses of wood fuels.

BURNER DATA SHEET

Mill Name ______________________________

Location ______________________________

Manager or Owner ______________________________

Date ______________ Time of Day ______________

Base Diameter ______________________________

Height ______________________________

Top Diameter ______________________________

Top Screen Type ______________ Size ______________

F. D. Fan Type ______________ Number ______________

F. D. Fan Horsepower ______________________________

Type Grates ______________ Area ______________

Grate Location ______________________________

Overfire Openings Size ______________ Number ______________

Overfire Openings Type ______________ Control ______________

Conveyor Inlet Height ______________ Size ______________

Relief Vents Type ______________ Size ______________

Burner Condition ______________________________

Fuel: Flights per minute ______________________________

Fuel Type ______________________________

Sawdust (lb per flight) ______________________________

Sawdust (lb per min) ______________________________

Sander Dust (lb per min) ______________________________

Planer Shavings (lb per min) ______________________________

Bark (lb per flight) ______________________________

Bark (lb per min) ______________________________

Rough Stock (lb per flight) ______________________________

Rough Stock (lb per min) ______________________________

Remarks: ______________________________

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STATE OF OREGON REGULATIONS

TO BE ADDED TO DIVISION 2, AIR POLLUTION, SUBDIVISION 1, DISCHARGE STANDARDS, SECTION 21-006, DEFINITIONS, CHAPTER 334

Definitions

"Overfire Air" means air introduced directly into the waste burner in the upper burning area around the refuse or fuel pile.

"Underfire Air" means air introduced into the waste burner under the fuel pile.

"Approved" means approved in writing by the Sanitary Authority staff.

"Wigwam Waste Burner" means a burner which consists of a single combustion chamber, has the general features of a truncated cone, and is used for incineration of wood wastes.

"Auxiliary Fuel" means any carbonaceous material which is readily combustible (includes planer ends, slabs, and sidings).

UNDER DIVISION 2, SUBDIVISION 2

Section One. Wigwam Burners - Purpose

Section One through Section Four are adopted for the purpose of preventing or eliminating air pollution or public nuisance caused by smoke, gases and particulate matter discharged into the air from wigwam waste burners.

Section Two. Wigwam Waste Burner Construction Prohibited

Construction of wigwam waste burners is hereby prohibited after July 1, 1965, unless plans and specifications have been submitted to and approved by the Sanitary Authority prior to construction.

Section Three. All Existing Wigwam Waste Burners Shall Comply by January 1, 1966, with the following:

1. Adjustment of forced-draft underfire air shall be by variable speed blower or fans, dampers or by-passes or by other approved means.

2. The introduction of overfire air shall be principally by adjustable tangential air inlets located near the base of the wigwam waste burner or by other approved means.

3. A thermocouple and pyrometer or other approved temperature measurement devices shall be installed and maintained. The thermocouple shall be installed on the burner at a location six inches above and near the center of the horizontal screen or at another approved location.

4. During burner operation the burner exit temperatures shall be maintained as high as possible so as to maintain efficient combustion.

5. A daily written log of the waste burner operation shall be maintained to determine optimum patterns of operation for various fuel and atmospheric conditions. The log shall include, but not be limited to, the time of day, draft settings, exit gas temperature, type of fuel, and atmospheric conditions. The log or a copy shall be submitted to the Sanitary Authority within ten days upon request.

6. Auxiliary fuel shall be used as necessary during startup and during periods of poor combustion to maintain exit temperatures required under Subsection 4. Rubber products, asphaltic materials, or materials which cause smoke discharge in violation of Section 21-011 or emissions of air contaminants in violation of Section 21-016 or Section 21-021 shall not be used as auxiliary fuels.

7. Light fuels or wastes shall be introduced into the burning area in such a manner as to minimize their escape from the burner.

Section Four. Variance

1. Waste burners operating within the modifications and criteria of Section Three are granted a variance for one year from the effective date of these rules from compliance with Section 21-011 Smoke Discharge, Section 21-016 Particle Fallout Rate and Section 21-021 Suspended Particulate Matter.

2. Wigwam waste burners located in sparsely populated areas of the state where their potential for causing an air pollution problem in the immediate or surrounding area is slight, may be granted variances from the provisions of Section Three pursuant to ORS 443.810.

ANALYSES OF WOOD FUELS

Analysis	Percent by Weight (Dry Basis) Redwood (Cedar)	Hemlock (White Fir)	Douglas-fir	Pine
Proximate Analysis				
Volatile Matter	82.5	74.2	82.0	79.4
Fixed Carbon	17.3	23.6	17.2	20.1
Ash	0.2	2.2	0.8	0.5
Ultimate Analysis				
Hydrogen	5.9	5.8	6.3	6.3
Carbon	53.5	50.4	52.3	51.8
Nitrogen	0.1	0.1	0.1	0.1
Oxygen	40.3	41.4	40.5	41.3
Sulfur	0	0.1	0	0
Ash	0.2	2.2	0.8	0.5
Heating Value Btu/lb	9220	8620	9050	9130

THE ENGINEERING EXPERIMENT STATION

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Engineering Experiment Station (established 1927)

Science Research Institute (established 1952)

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